



Microhabitat Ecology of Mosquitoes in Port Harcourt Metropolis and Environs

Ogugua K. Ogbalu^{1*} and John N. Onwuteaka¹

¹Department of Applied and Environmental Biology, River State University of Science and Technology, P. M. B. 5080, Port Harcourt, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The relative abundance of the of three mosquito groups namely Anopheles, Culex and Aedes distribution was studied within Port Harcourt Metropolis (latitude 4°43'E – 4°50' E and longitude 6° 57'N – 7°05'N). Collections of mosquitoes and the volume of water were from twenty three microhabitats. The microhabitats were subdivided into Human_Use micro-habitats (HUM) and Vegetation microhabitats (VDM). The results show the dominance of three mosquito groups belonging to three genera (Anopheles, Culex and Aedes species. From a total of 2101 mosquito larvae, Vegetation derived microhabitats showed 526 (10.6%) were from Paw-Paw Stems; 485 (9.7%) from Flower Pots; 406 (8.2%) from Coconut husks; 317 (6.4%), from Palm tree trunk; 110 (2.2%) from tree trunks; 65 (1.3%) from Pine Apple axils; 61 (1.2%) from Banana axils; 53 (1.1%) from Cocoyam axils; 46 (0.9%) from Plantain axils and 32 (0.7%) from mushrooms. From a total of 3357 mosquito larvae the mosquito abundance from human-derived microhabitats shows a total of 637 (12.4%) were from Septic tanks, 485 (9.7%) from flower pots, 455 (9.2%) from Refuse Dumps, 410 (8.2%) from Cups, 340 (6.8%) from Containers, 291(5.9%) from Earthenware Pots, 287 (5.8%) from Plastic Chairs, 125 (2.5%) from Plastic shoes, 110 (2.2%) from leather shoes, 93 (1.6%) from Sachet water, 66 (1.6%) from Plastic plates, 30 (0.6%) from Spoons, 19 (0.4%) from Canvas shoes and 10 (0.3%) from Cream Containers. No marked significant difference among the microhabitats ($p < 0.05$) were shown from an ANOVA analysis between the Human_Use derived micro-habitats

*Corresponding author: E-mail: ogbaluo@yahoo.com;

(HUM) and Vegetation derived microhabitats (VDM). The likely adaptation to diversity of habitats is adduced as a function of oxygen availability with the right physicochemical conditions especially for the Anopheles group. Further studies on a geographic scale are needed to identify the inherent risk of any emerging ecological adaptations and potential threat to public health.

Keywords: Micro-habitats; mosquitoes; anopheles; culex; aedes; abundance.

1. INTRODUCTION

Mosquitoes, belong to the Culicidae family within the order Diptera, and consist of about 3,500 species distributed worldwide. Within this numerous species only a few within the Anopheles, Aedes, and Culex genera have been well described owing to their medical significance [1]. The medical and socioeconomic impact of the diseases caused by mosquitoes has caused many control measures to be developed. However it is evident that as habitats change due to economic activities in addition to new consumption patterns, new microhabitats are created that provide potential favorable sites for mosquito breeding and transmission efficiency. Environment determines the distribution of the mosquito insects in that it influences the vector distribution, abundance and diversity. Because these vectors spend the first three of their four life stages in aquatic habitats understanding microhabitat ecology of mosquitoes is therefore a critical component in designing vector control. In this study, we analyze the relationship between different microhabitats evaluated at random (presence, abundance and diversity) of mosquito species vectors in Port Harcourt Metropolis.

2. MATERIALS AND METHODS

2.1 Study Site

The study site is located in Port Harcourt and environs (Fig. 1). Port Harcourt City lie between latitude 4°43'E – 4°50' E and longitude 6°57'N – 7°05'N. Port Harcourt is a densely populated city with human intensive activities in different sectors ranging from food vendors, restaurants, open stall markets, transportation, rental apartments with sub-standard sanitation and waste management infrastructure, indigenous residential homes, auto-workshops waste dump sites at various locations within the city and perennial drainages that crisscross throughout most of the city. The western border of the city is the New Calabar River, a tidal freshwater characterized by moderate to high riparian vegetation. On the eastern border are five other

streams namely Ntawogba, Miniweja, Miniokoro, Minichida and Agbonchia Stream that drain the Port Harcourt catchment and finally empty into Bonny estuary. Cultivated croplands are also visible in communities at the outskirts of the city fringes which include Plantains, Pineapples, Yam and Corn. The climate is tropical, with high rainfall and annual precipitation of 2,372 mm of which nearly half could be attributed to precipitation from May through July, 2010. The average annual mean relative humidity is 86% (66-96%) with mean annual temperature of 25°C ranging from 22°C to 32°C.

2.2 Mosquito Collection

Mosquitos were collected from twenty four microhabitats namely Sachet water, Containers, Refuse drums, Plastic chairs, Coconut husks, Earthenware pots, Flower pots, Plastic plates, Spoons, Cups, Cream containers, Pawpaw stems, Tree holes, Cocoyam axils, Pineapple axils, Banana, axils, Plantain axils, Palm tree trunk, Mushroom, Shoe [leather], Shoe [plastic], Shoe [canvas], Septic tanks, Pools of water. In the laboratory, mosquitos' identification was aided by published pictorial keys for Culicines [2] and Anopheline mosquitoes Gillies and Coetzee [3]. Each collection was recorded to align with the microhabitat. The difference in distribution of mosquito larvae in the microhabitats, were subjected to statistical analysis using JMP SAS software. Analysis of Variance and Student's t-tests were used to determine the levels of the significance of the occurrence of each mosquito group in the different microhabitats.

3. RESULTS

Figs. 2 – 3 shows the abundance and percentage occurrence of mosquitoes in human-use and vegetation derived microhabitats. The Human-use derived habitats accounted for a total of 3357 which make up 65% of mosquito larvae while the vegetation derived microhabitats accounted for 2100.5 mosquito larvae consisting of approximately 42% of total mosquito larvae collected.



Fig. 1. Study area showing Port Harcourt and environs

Fig. 2 shows the abundance of larvae collected from all the vegetation derived microhabitats. From a total of 2101 mosquito larvae 526 (10.6%) were from Paw-Paw Stems; 485 (9.7%) from Flower Pots; 406 (8.2%) from Coconut husks; 317 (6.4%), from Palm tree trunk; 110 (2.2%) from tree trunks; 65 (1.3%) from Pine Apple axils; 61 (1.2%) from Banana axils; 53 (1.1%) from Cocoyam axils; 46 (0.9%) from Plantain axils and 32 (0.7%) from mushrooms.

In Fig. 3 the mosquito abundance from human-derived microhabitats shows that from a total of 3357 mosquito larvae 637 (12.4%) were from Septic tanks, 485 (9.7%) from flower pots, 455 (9.2%) from Refuse Dumps, 410 (8.2%) from Cups, 340 (6.8%) from Containers, 291 (5.9%) from Earthenware Pots, 287 (5.8%) from Plastic Chairs, 125 (2.5%) from Plastic shoes, 110 (2.2%) from leather shoes, 93 (1.6%) from Sachet water, 66 (1.6%) from Plastic plates, 30 (0.6%) from Spoons, 19 (0.4%) from Canvas shoes and 10 (0.3%) from Cream Containers.

In Fig. 4a combination of human and vegetation derived habitats shows that from a total of 4973

mosquito larvae the percentage abundance of mosquito larvae above five percent of the total rank in descending order as Septic Tank>Pawpaw Stems>Flower Pots> Coconut husks/Cups>Containers> Palm tree trunks>Earthenware Pots> Plastic Chairs.

A one way analysis of variance of means by microhabitat (Fig. 5) showed that there was no marked significant difference among the microhabitats ($p < 0.05$) between the Human_Use derived micro-habitats (HUM) and Vegetation derived microhabitats (VDM).

Figs. 5-7 shows the abundance of mosquito types in the microhabitats. The Anopheles constitutes 26.3% with highest abundance in the following order; Septic tanks>Paw-paw stems>Flower pots>Palm tree trunks>Cups>Coconut husks and earthenware pots. The Culex group was the most abundant group with a 64.1% occurrence with highest abundance in the following order; Flower Pots>Paw-Paw Stems; Septic tanks>Coconut husks>Refuse drums>Cups>Plastic chairs> Palm tree trunk>Earthenware pots > Containers.

The Aedes group were the least abundant at 9.6% occurrence and rank in the following order namely Containers> Septic tank> Refuse drums> Cups>Paw-paw stems and Earthenware pots.

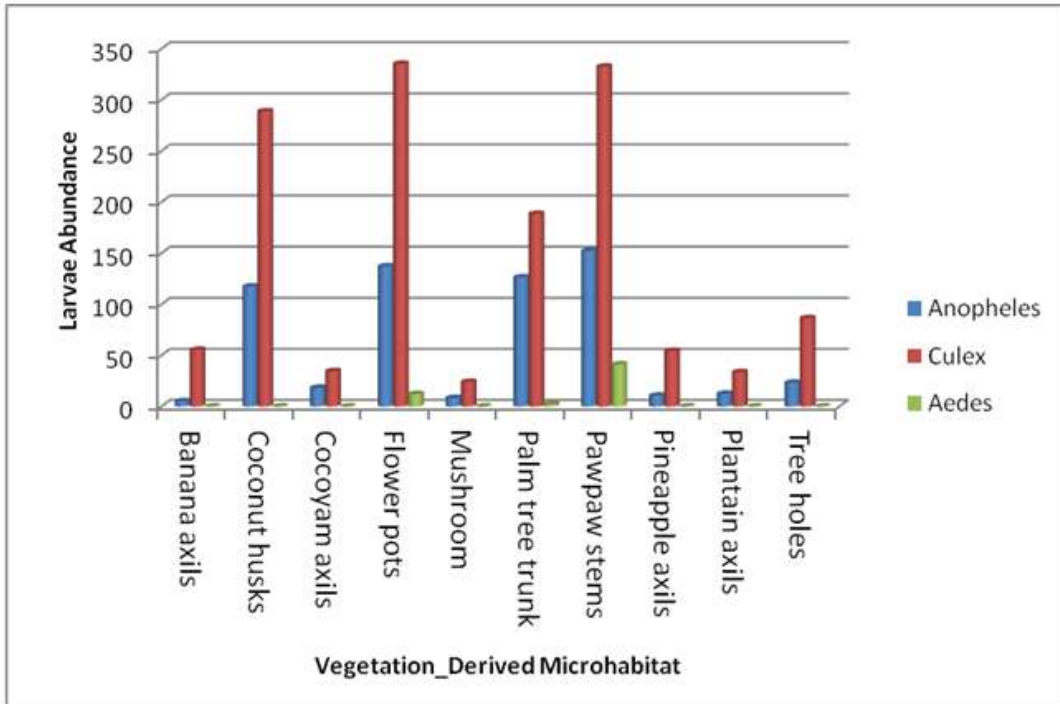


Fig. 2. Abundance of larvae from vegetation derived microhabitats

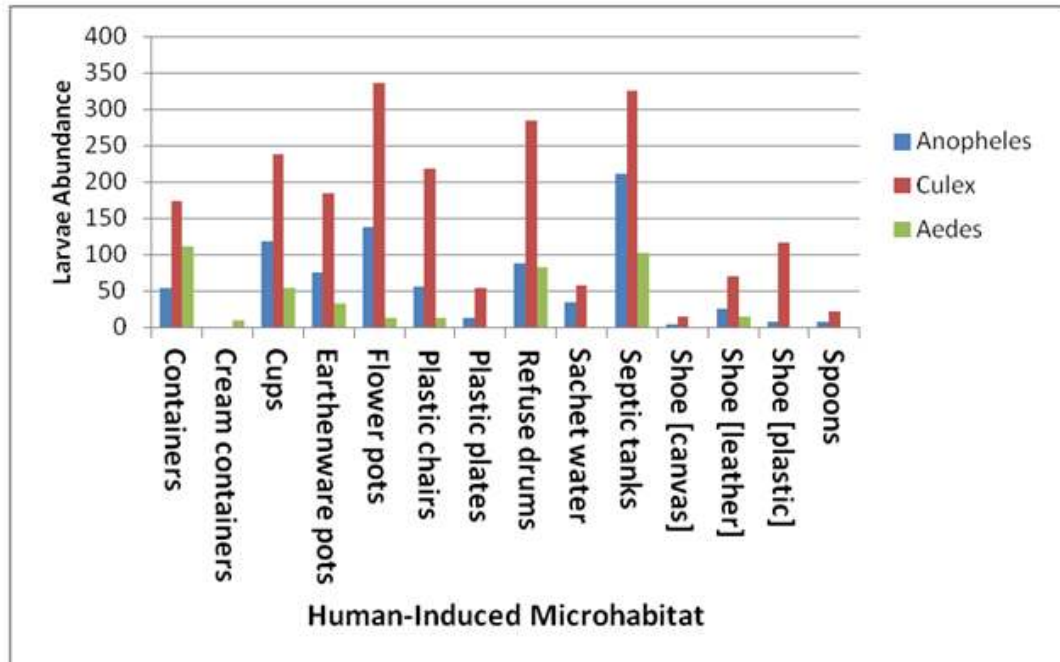


Fig. 3. Abundance of larvae from Human-Use microhabitats

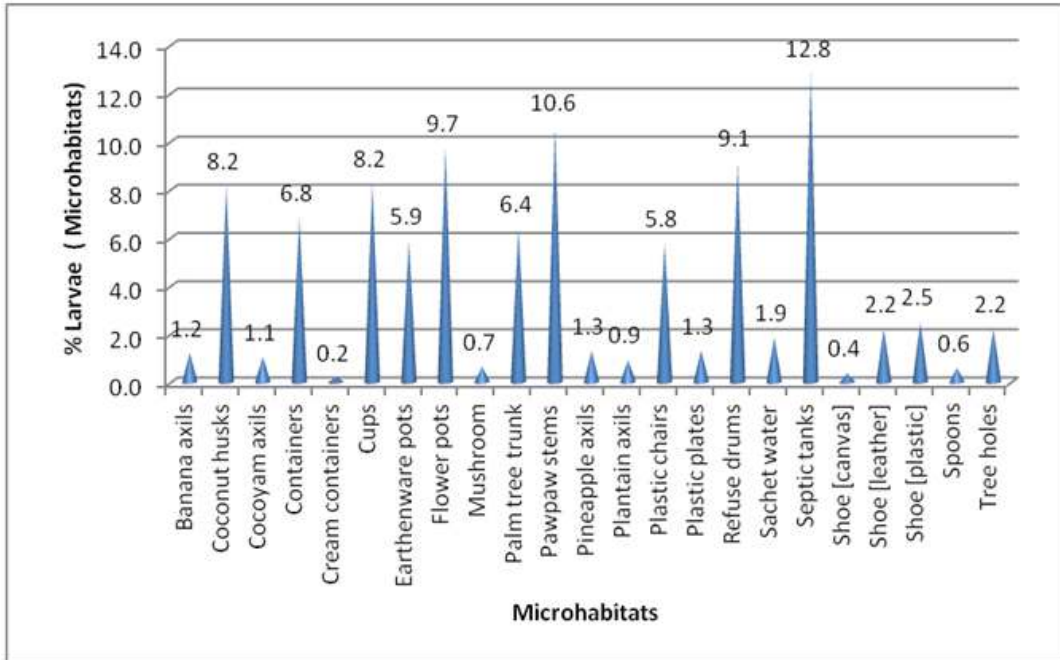


Fig. 4. Percentage abundance of larvae in all the microhabitats

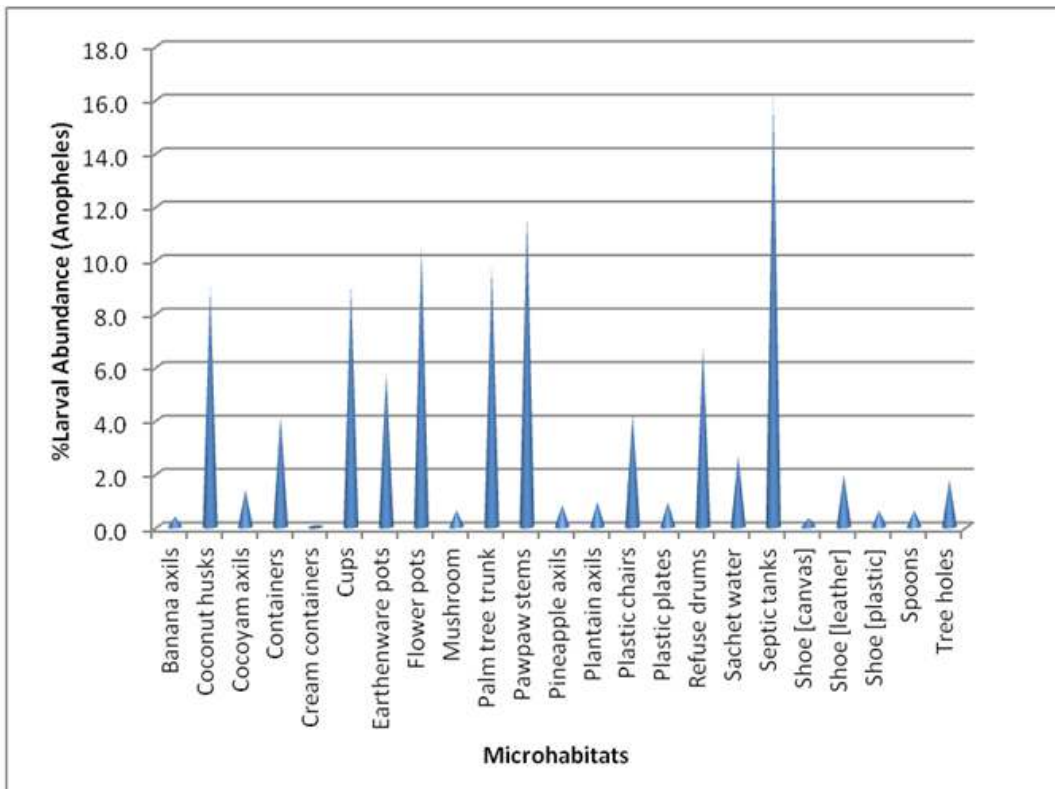


Fig. 5. Anopheles larvae abundance in different microhabitats

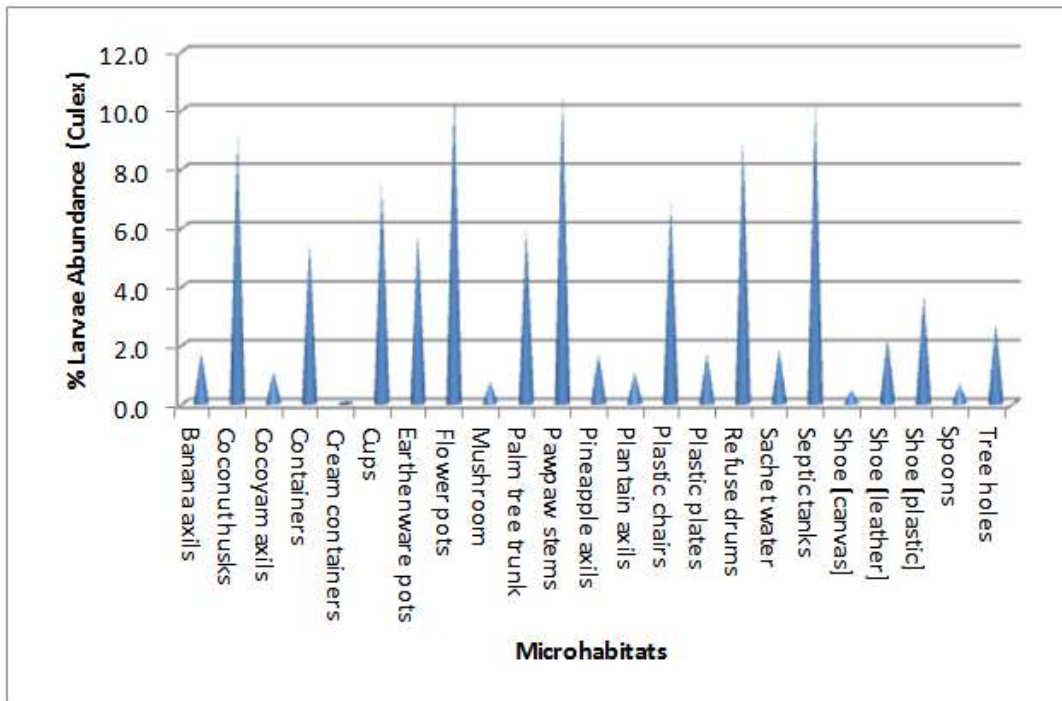


Fig. 6. Culex larvae abundance in different microhabitats

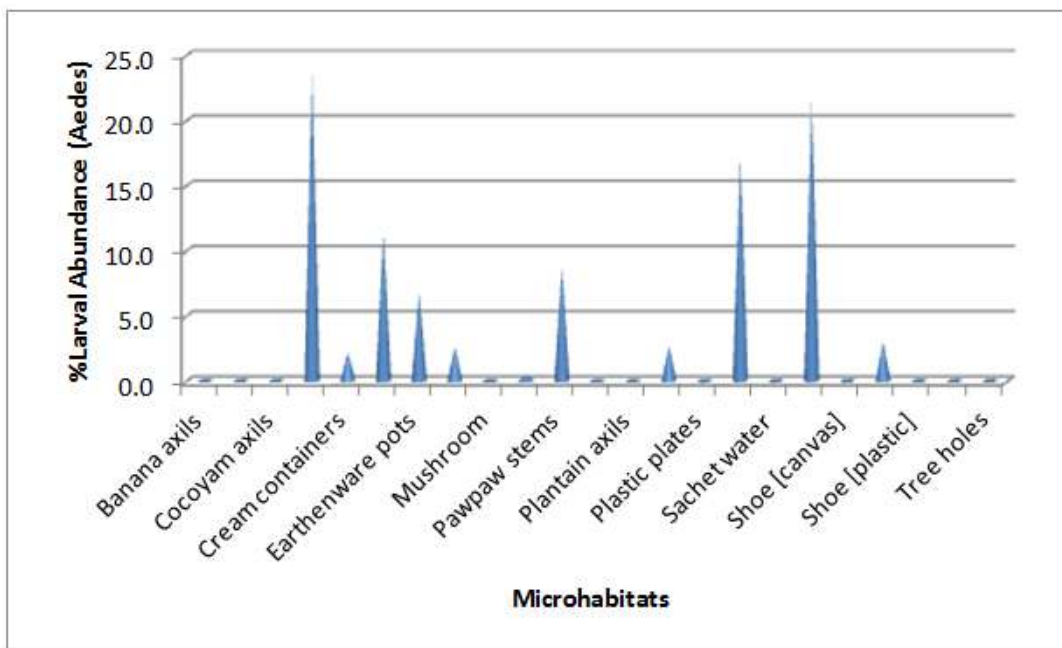


Fig. 7. Abundance of larvae from human-use microhabitats

For each mosquito group in Figs. 8–10, differences between Human-use and Vegetation derived microhabitats which were tested with One-Way Analysis of Variance show evidence of no significant differences in the group means

except in Fig. 10. Fig. 10 shows evidence of differences between the group means and in the overlap marks in the means diamond with a borderline significant difference ($p < 0.05$) in the comparison circles of the group means.

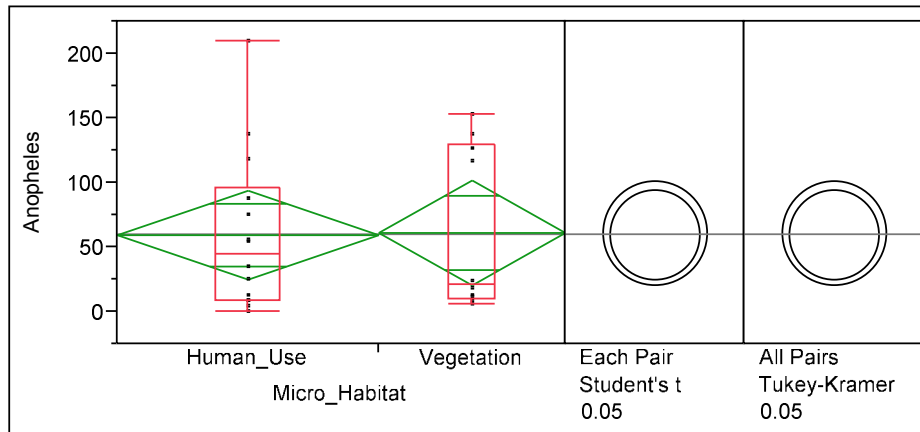


Fig. 8. Oneway analysis of variation of Anopheles abundance by Micro_Habitat

LSD threshold matrix

Abs(Dif)-LSD	Vegetation	Human_Use
Vegetation	-57.555	-51.634
Human_Use	-51.634	-48.643

Positive values show pairs of means that are significantly different; Detailed Comparisons Report

Comparing vegetation with Human_Use

Difference	1.651	t Ratio	0.064274
Std Err Dif	25.694	DF	22
Upper CL Dif	54.937	Prob > t	0.9493
Lower CL Dif	-51.634	Prob > t	0.4747
Confidence	0.95	Prob < t	0.5253

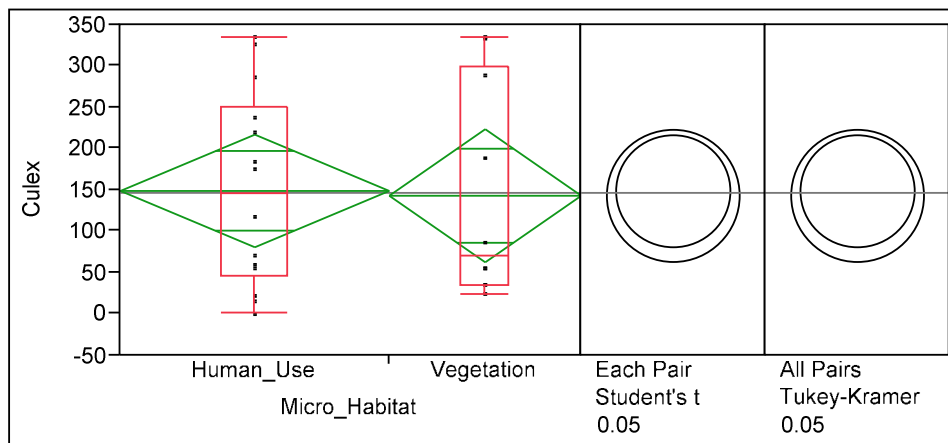
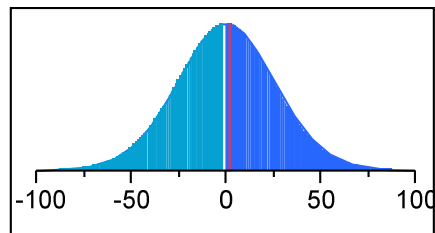


Fig. 9. Oneway analysis of variation of Culex abundance by Micro_Habitat

LSD threshold matrix

Abs(Dif)-LSD	Human_Use	Vegetation
Human_Use	-96.37	-99.50
Vegetation	-99.50	-114.02

Positive values show pairs of means that are significantly different.
Detailed Comparisons Report
Comparing Vegetation with Human_Use

Difference	-6.07	t Ratio	-0.11919
Std Err Dif	50.90	DF	22
Upper CL Dif	99.50	Prob > t	0.9062
Lower CL Dif	-111.63	Prob > t	0.5469
Confidence	0.95	Prob < t	0.4531

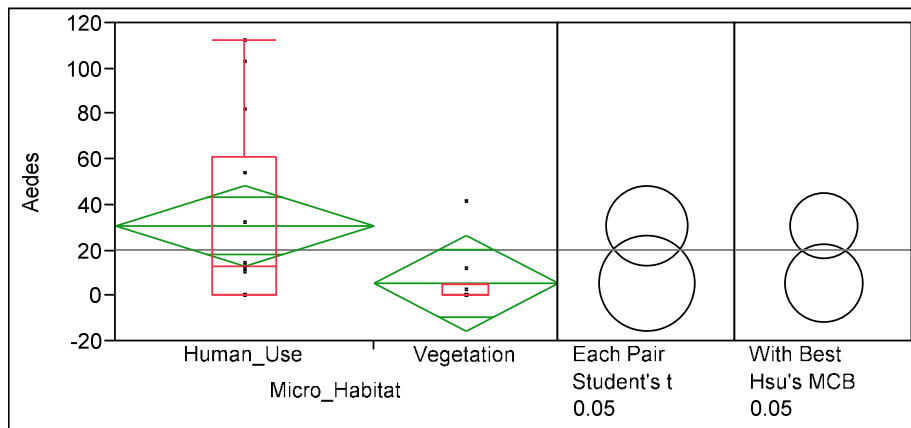
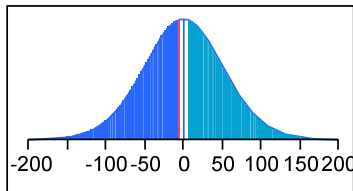


Fig. 10. Oneway analysis of variation of Aedes abundance by Micro_Habitat

LSD threshold matrix

Abs(Dif)-LSD	Human_Use	Vegetation
Human_Use	-25.106	-2.190
Vegetation	-2.190	-29.706

Positive values show pairs of means that are significantly different.
Detailed Comparisons Report
Comparing Vegetation with Human_Use

Difference	-25.313	t Ratio	-1.90876
Std Err Dif	13.261	DF	22
Upper CL Dif	2.190	Prob > t	0.0694
Lower CL Dif	-52.815	Prob > t	0.9653
Confidence	0.95	Prob < t	0.0347*

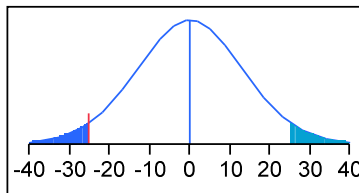


Fig. 11 shows a correlation of the volume of water to abundance of mosquito larvae collected from all the microhabitats. The chart shows the abundance of larvae on the y-axis ranging from 100 to 600 while the volume of water in milliliters is on the X-axis with values ranging from 500 ml to 3000 ml. There is evidence of a positive trend which shows that the samples with higher volume tended to have higher abundance implying positive trend of one variable implying high values of the other. The confidence ellipsoids shown by the red line indicate that samples from this population are likely to lie within this region demonstrating this upward positive trend. The Pearson statistics for the two variables of mosquito abundance and volume of water (ml) is $r = 0.6149$ indicating a moderate positive relationship between the two variables. Due to the skewed distribution of the two variables a calculated Spearman's statistics ($r = 0.6781$) shows consistency with the Pearson statistics and this provides a similarity in the conclusion.

4. DISCUSSION

The survey of twenty three microhabitats have shown lack of evidence of discrimination between Human-Use and Vegetation derived microhabitats as favorable sites for oviposition and breeding among these three groups of mosquitoes. However the marginal significant difference ($p < 0.05$) and the variation shown by the box-plots (human and vegetation microhabitats) in abundance of *Aedes* species shows the difficulty in the prediction of favourable or preferred habitats for this group. This lack of any preference between human derived and vegetation derived habitats have been documented in a number of authors [4-9]. Six microhabitats which are evidently common to all the mosquito groups as shown in Figs. 12-14 were Septic tanks, Paw-Paw stems; Refuse Dumps, Cups, Containers and Earthenware Pots.

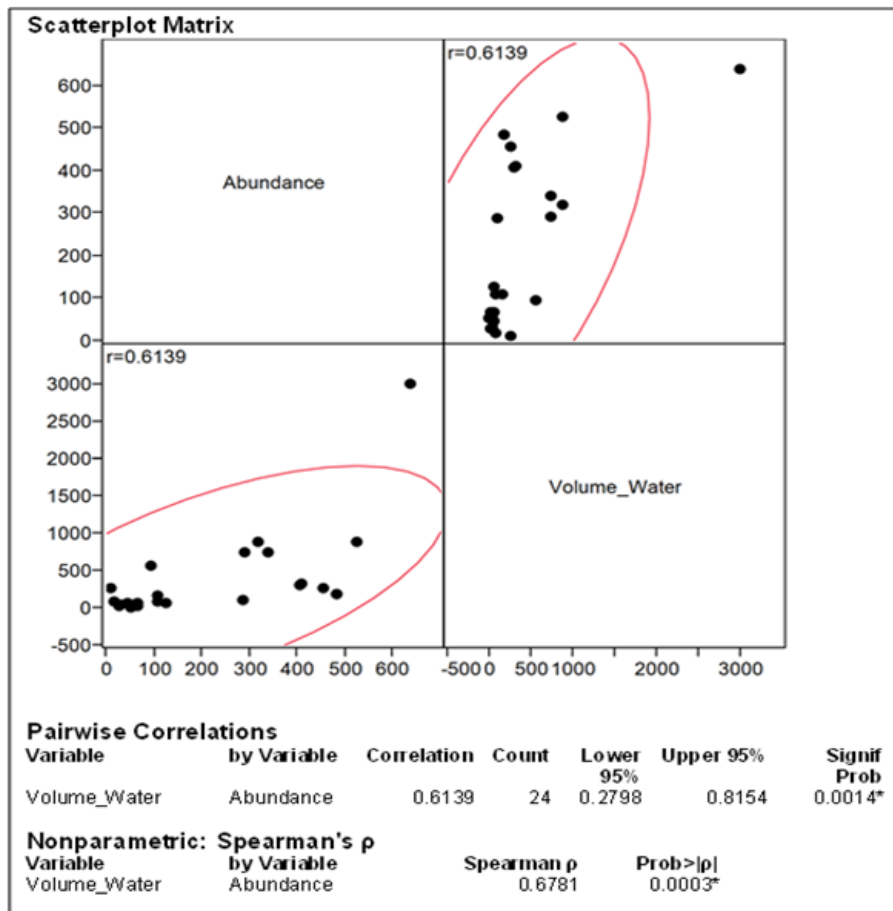


Fig. 11. Correlation matrix of volume of water (ml) and mosquito abundance

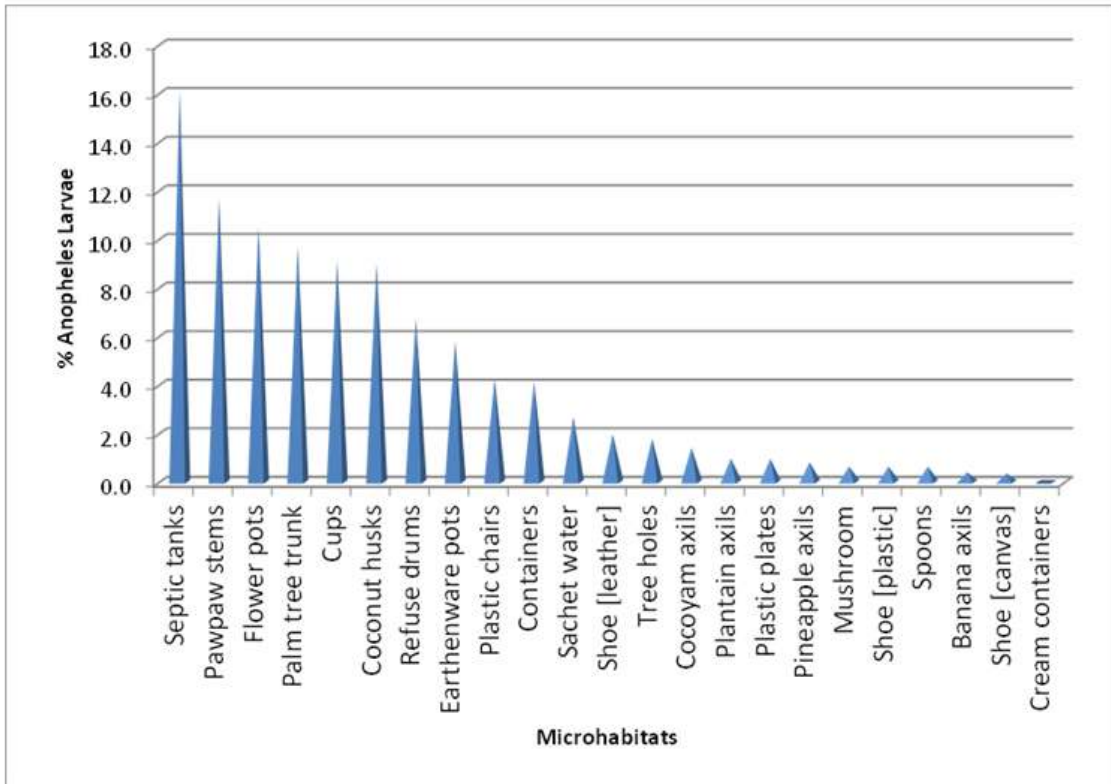


Fig. 12. Ranked percentage occurrence of Anopheles in microhabitats

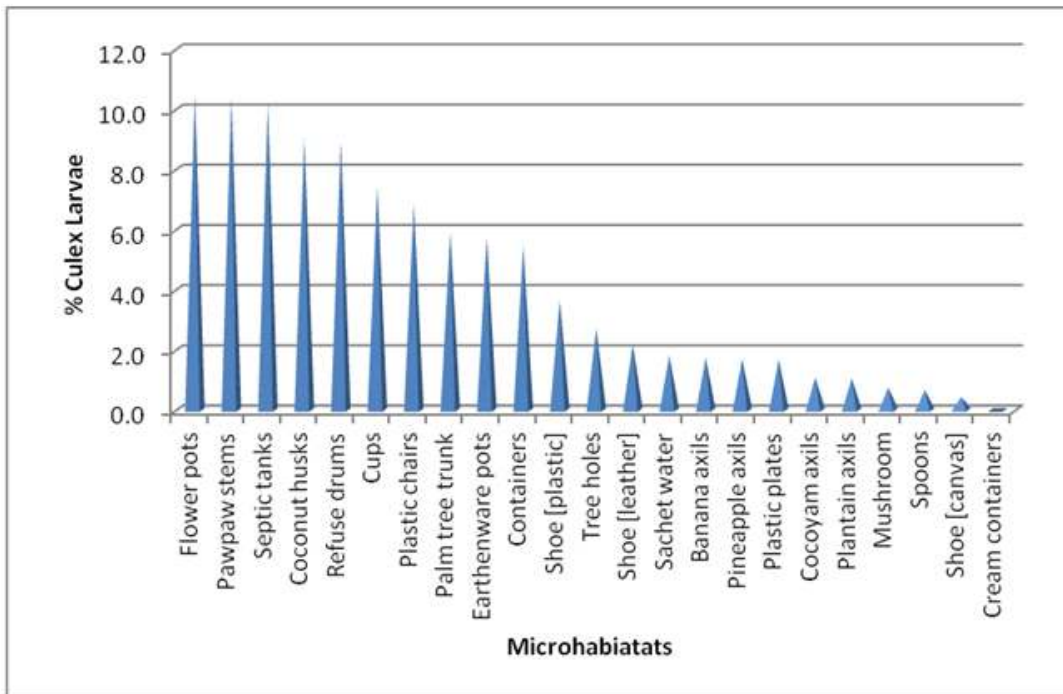


Fig. 13. Ranked percentage occurrence of Culex in microhabitats

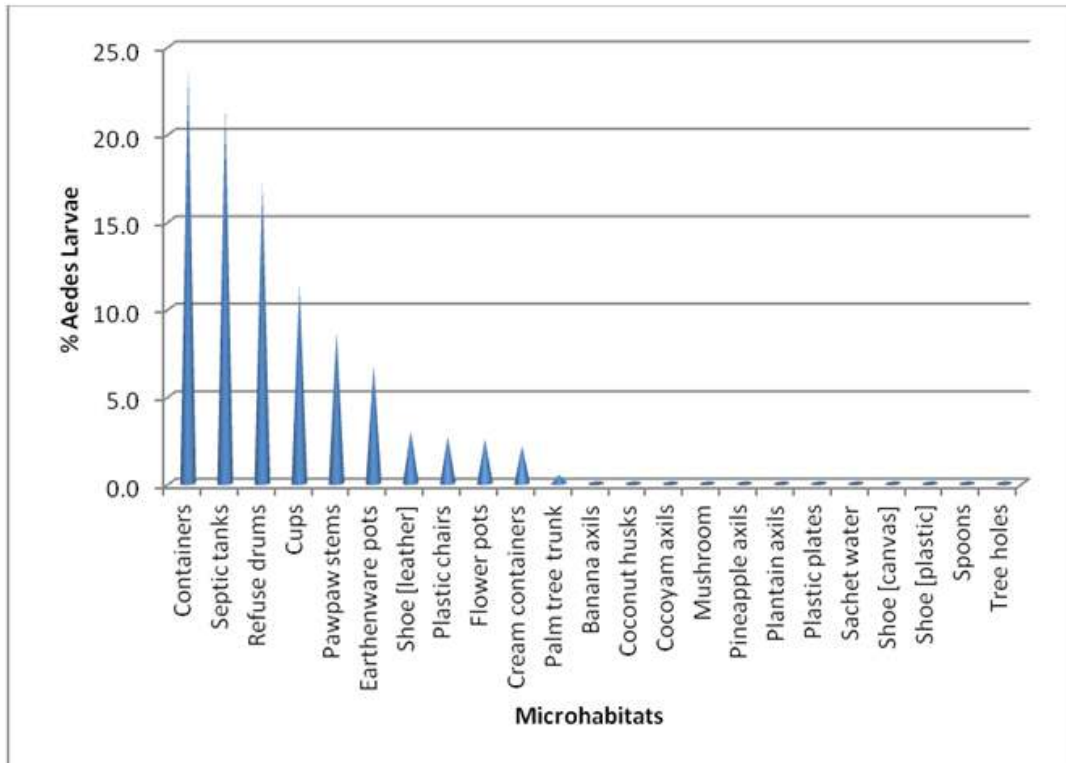


Fig. 14. Ranked percentage occurrence of Aedes in microhabitats

Septic tanks are proven popular microhabitats for Culex and Aedes mosquito breeding [10-13]. The percentage abundance of Anopheles mosquito (16.1%) group over that of Culex (10.2%) has an important public health control implications as Anopheles prefer sunlit and clear breeding places [14-16], in contrast to the enclosed nitrate and ammonia rich microhabitat of latrines and septic tanks. Paw-Paw Stems supported Anopheles abundance more than Culex and Aedes presumably due to the clear and open sunlit microhabitat of the split hollow stems of the Paw-Paw tree. The Anopheles larvae is known to lack a respiratory siphon. Therefore their abundance is plausibly a result of favourable water physico-chemistry which is advantageous to Anopheles whereby they can position their body parallel to the surface of the water to breathe through spiracles located on the 8th abdominal segment. Refuse dumps supported more Aedes (17.2%) than Culex (8.9%) and Anopheles (6.7%) in agreement with the known exploitation by Aedes of a wide range of breeding habitats with different temporal characteristics reflecting the broad environmental adaptability of the Aedes species [17-19]. A

similar occurrence of abundance pattern is seen in microhabitats represented by Cups, Containers and Earthenware Pots which also supported more Aedes (11.4%; 23.5%; 6.8%) Anopheles (9.1%; 4.1%; 5.8%) and Culex (7.1%; 5.5%; 5.8%).

This study provides evidence of the potential wide adaptability of different mosquito groups in microhabitats previously not considered favourable. It is plausible that with the right conditions of humidity and temperature in stagnant water, any microhabitat whether from Human-use or Vegetation can provide a suitable environment for oviposition and breeding. Because oxygen acquisition is central to behavioral and morphological features associated with most other activities (trophic, physical constraints, biotic interactions), it seems a plausible factor influencing the utilization of the diversity of habitats currently emerging as a result of human activities. The likely adaptation of the three mosquito groups to a wide range of habitats as a result of significant environmental and demographic changes is a factor that needs to be addressed through additional studies on a

geographic scale. Such would help to identify the risk inherent in any emerging ecological and physiological adaptability and potential threat to public health.

5. CONCLUSION

The study has provided further evidence to a growing body of literature, on the adaptation of mosquito species to micro-habitats being created, as a result of urbanization and modification of vegetation habitats. Understanding many of the emerging microhabitat characteristics that can act to promote and increase the probability of the transmission of pathogens is necessary, for the development of effective control measures.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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